HALIDE-LEACHING EFFECTS ON CHLORINE-36 STUDIES AT YUCCA MOUNTAIN

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RESEARCH OBJECTIVES

Chlorine-36 generated from worldwide nuclear tests in the 1950s and 1960s has been used to identify fast flow paths at Yucca Mountain, Nevada, the proposed site for a national high-level nuclear waste repository. *Fast flow* refers to preferential transport of water through faults or fractures in surrounding rock media with relatively low permeability. Bomb-pulse ^{36}Cl carried into the subsurface by infiltrating rainwater presumably resides along fracture surfaces. However, leaching a rock sample to extract this salt inevitably extracts pore-water chloride (Cl) and rock chloride from the matrix as well. The work described here contributes to the understanding of leaching processes for the ongoing validation study of ^{36}Cl at Yucca Mountain.

APPROACH

In this work, we developed both a conceptual and numerical model (as well as a mathematical solution) for leaching processes. First, an analytical solution for diffusion of Cl and ^{36}Cl in composite media (rock matrix and water) was derived to accommodate variable diffusivity. Second, a leaching model was developed to take into account various Cl sources, including matrix pore water and less-easily-leached components (isolated fluid inclusion and mineral boundary salts). Third, the leaching model was applied to samples from Yucca Mountain stratigraphic units—the Tiva Canyon welded tuff (TCw), the Paintbrush nonwelded tuff (PTn), and the Topopah Spring welded tuff (TSw) .

ACCOMPLISHMENTS

Our models successfully examined the role of sample leaching in the ^{36}Cl studies at Yucca Mountain. They simulated the effect of leaching time, sample size, and active and passive leaching. Model results show that the probability of detecting a ^{36}Cl/Cl bomb-pulse signal was severely diminished at longer leaching times and with smaller rock fragment sizes (Figure 1). Bomb-pulse signals in the TSw welded tuff were the least suppressed, because of lower concentrations in the pore water. However, bomb-pulse signals at TCw and PTn were "masked" (had limited detectability) because of higher matrix-pore-water Cl concentrations. Leaching times of 1 to 10 hours were more likely to reveal detectable bomb-pulse signals (if they were present). Bomb-pulse ^{36}Cl/Cl ratios were also more likely to be obtained when pore-water Cl concentrations were initially low.

SIGNIFICANCE OF FINDINGS

These research results demonstrate the effects of various factors in leaching experiments, and provide much-needed theoretical guidelines for leaching protocols of

^{36}Cl study. The findings are expected to shed a great deal of light on the reproducibility debate in current ^{36}Cl validation studies.

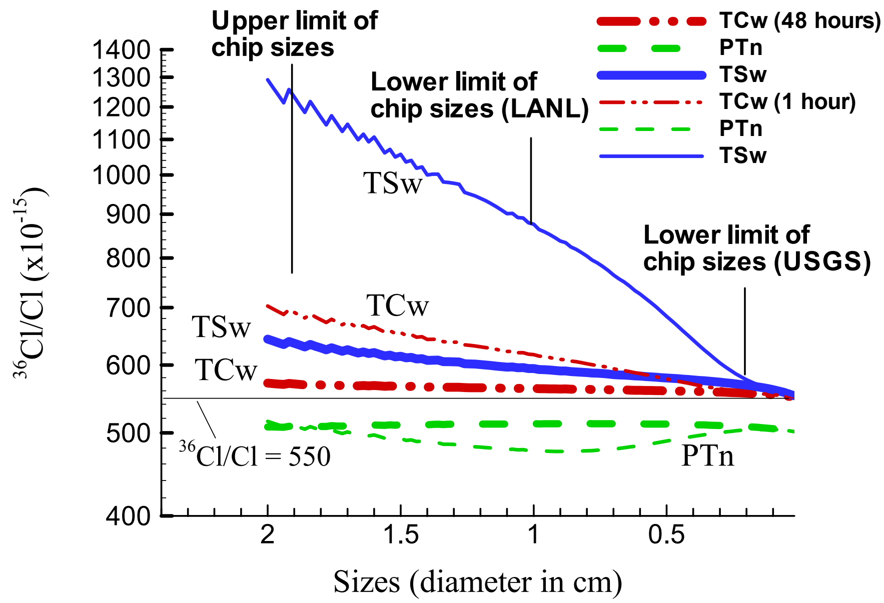
RELATED PUBLICATIONS

Lu, G., E. L. Sonnenthal, and G. S. Bodvarsson, Implications of halide leaching on chlorine-36 studies at Yucca Mountain, Nevada. Water Resources Research, 2003 (submitted).

ACKNOWLEDGMENTS

This work was supported by the Director, Office of Civilian Radioactive Waste Management, U.S. Department of Energy, through Memorandum Purchase Order EA9013MC5X between Bechtel SAIC Company, LLC, and the Ernest Orlando Lawrence Berkeley National Laboratory (Berkeley Lab). The support is provided to Berkeley Lab through the U.S. Department of Energy Contract No. DE-AC03-76SF00098.

Figure 1. Model results indicating effects of chip size, leaching time, and rock pore water composition on $^{36}Cl/Cl$ for leachate at 1 hour and 48 hours simulated leaching time presented for rock samples from TCw, PTn, and TSw



Upper limit of chip sizes
Lower limit of chip sizes (LANL)
Lower limit of chip sizes (USGS)
TCw (48 hours)
PTn
TSw
TCw (1 hour)
PTn
TSw
TSw
TCw
TSw
TCw
PTn
$^{36}Cl/Cl = 550$
$^{36}Cl/Cl$ ($x10^{-15}$)
1400
1300
1200
1100
1000
900
800
700
600
500
400
2
1.5
1
0.5
Sizes (diameter in cm)